Improvements relating to rotary engines

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Abstract

PATENT SPECIFICATION

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PROVISIONAL SPECIFICATION.

Improvements relating to Rotary Engines.

We, WILLIAM ROBERT CROSS, of 10, Avenue House, Henry Street, St. John's Wood, London, N.W. 8, British Subject, and ALBERT EDWARD HAY, a British Subject, of Oak Lodge, Nathan Road, North Wembley, in the County of Middlesex, do hereby declare the nature of this invention to be as follows:—

An engine in which the main parts may be described as Stators and Rotors. Rotors revolve inside Stators. Both bodies have smooth surfaces in close juxtaposition to one another, but prevented from binding or gripping by a film of lubricating medium, which film serves not only to conduce to free movement of rotors within stators, but also to preserve gas or steam-tight joints between such rotors and stators. Cylinders are carried on or within the rotors, and cylinder-heads are fixed on the stators. Cylinders and cylinder-heads may be arranged in any desired manner so as to obtain at least two power strokes from each cylinder in every revolution of the rotors, as later described herein.

In this invention, a successful endeavour has been made to reduce moving and reciprocating parts to a low number, and to obtain a maximum of power, utilising a minimum of weight, by increasing the number of power strokes per revolution of the driving shaft. A four-cylinder internal combustion engine of the nature described herein will give eight or more power strokes per revolution. The principle of this engine may be applied to steam-driven, and Diesel or Semi-Diesel motors. When the exhaust gases or steam are fed to low-pressure cylinders, as later described, then the number of power strokes per revolution will be further increased.

For the purpose of ensuring a clear understanding of the principle of this invention, the description which follows assumes the use of the said principle in an internal combustion engine wherein power is generated by the explosion of compressed gaseous mixtures by a suitably-timed sequence of electric sparks.

A rotor, A, (which may be of solid material, or built up of castings, in wheel form), is secured at its boss, B, by a key, C, to the main driving shaft, D, as shown in Figure 1 of the accompanying drawings. The rotor, A, is machined to a polished surface at its periphery, E, so as to make, when suitably lubricated, (and, if necessary, fitted with gas-tight rings, such as, but not necessarily in the precise form shown at, *r*, in Figure 2), a gas-tight clearance from a polished and lubricated surface, F, on the inside of a stator, G. Stator, G, can be bolted to its bed by means of suitable brackets such as, H, in Figure 1. Cylinders, J, may be bored in, or affixed to, Rotor, A. These cylinders may be one, two, or more per rotor, A, and spaced at any required suitable distance from one another around the periphery, E. The placement of cylinders, J, and the like, may be at any angle found most suitable or efficient, and cylinder walls between X and rotor-face, E, (Figure 1) need not necessarily be straight, but may be shaped as found necessary. As shown in Figure 1 of the accompanying drawings, taking the base-line drawn through centres of exhaust ports, K, K, the angle of cylinders, J, J, relative to K, K, is 45 degrees. The distance between cylinder-heads, Y, Y, and exhaust ports, K, K, may also be any one found most suitable, but as shown, with lines drawn through centres of K, K, and *y*, *y*, the angle is 90 degrees.

The principle of the engine may now be described as follows: (bearing in mind the contents of the fourth paragraph aforegoing),

A charge of atomised gas is sucked through Induction Pipe, L, (Figure 2) by a double-acting, or other suitable, piston, M, working within a cylinder, N, affixed to the stator, G, (fig. 3). The cylinder, N, may be fixed centrally or otherwise between rotors, A, and A1, on the stator, G, (Fig. 2) so as to serve two cylinder-heads, Y, Y1, through short induction pipes, V, and V1.

The gas sucked into N, by M, through L, via an automatically or mechanically operated inlet valve, O, (Figure 3) (automatic or mechanically operated outlet valve, P, meantime being shut), is, one

quarter of a revolution of the rotor, A or A1, later, compressed by the return stroke of M, and forced through valve, P, to cylinder-head, Y1, (shown in Figure 2). At the moment of end of travel of M, the valve, P, shuts, and cylinder-head, Y1, is full of compressed and explosive mixture. At this same moment a spark is caused at the sparking points of sparking-plug, Q, and the resultant explosion drives the piston, R in Fig. 1, (which may be fitted with piston-rings, xV), and piston guide rod, S, up against compression spring, T, which is anchored at its base to cylinder cover-plate, U, affixed to cylinder, J, as shown in Figure 1. Cylinders, J, and the like, may be constructed to have cooling fins such as, Z, to prevent undue heating). The cover-plates, U, have a hole, W, through which guide-rod, S, can travel. The direct push of piston R, caused by the explosion, is transmitted to the rotor, A, by the spring, T, (which may, under certain circumstances, be dispensed with and substituted by any practicable means—such as air-compression,—whereby the sudden drive of the piston, R, may be partially relieved, although it is obvious that any substitute for the spring, T, must efficiently transmit the power generated by the moving piston, R, without loss) to the rotor, A, which is caused to revolve in the direction of the line of drive of R.

Meanwhile, other cylinder-heads, firing at the same time, are going through a similar cycle of operations, and the power derived is additive. A fraction of a revolution later, (which may conveniently be one quarter revolution), of the rotor, A, the expanded gas is expelled through an exhaust port, K, by the piston, R, which is forced back to its natural position of rest by the spring, T. The piston, R, on returning to its normal position of rest, comes against a suitable stop, X, which may be padded on the face nearest to R, with shock-absorbing material. See Figure 1. The gas expelled through port, K, is led either to the atmosphere or to low-pressure cylinders, (as in Figure 4, for example), where its pressure may be further utilised to add to generated power. A fraction of a revolution later, (which may conveniently be one quarter of a revolution, as shown in Figure 1), the rotor, A, has reached such a position that the aforementioned cylinder, J, is in position to receive another exploded charge of gas, and so the cycle of operations is continued, so that every rotor-cylinder can deliver at least two power strokes per revolution of A.

All cylinder-heads, Y, Y1, and the like, may, if necessary, be in line with one another, along the whole length of the engine, and the cylinders, J, J1, and the like, (in rotors A, A1 and the like), may be staggered at various angles relative to one another. With such an arrangement, and with explosions of gas timed to take place at desired moments, an even torque with very little vibration is obtained. For example, an eight-rotor engine of this type, having, for example, two cylinders in each rotor, (that is to say sixteen cylinders in all), will give thirty-two power strokes in each revolution of the main shaft, D, without taking into consideration the fact that additional power strokes can be obtained if the exhaust gases are utilised in low-pressure cylinders as heretofore mentioned, and shown in Figure 4 of the accompanying drawings. In such a multi-cylinder engine, the rotor, A, may quite conveniently be constructed as one mass, if necessary, and not as several individual rotors, keyed to the main shaft, D, at each end.

It is arranged that the main shaft, D, shall drive the auxiliary shafts, D1 and D2, through a two-to-one chain and/or gear and shaft drive, so that D1 and D2 shall revolve at twice the speed of D. (See dw, $dw1$, and $dw2$, in Figure 2). The shafts D1 and D2, secured to the stator, G, by suitable brackets, such as, e, shall drive all auxiliary parts of the engine, such as electrical generators, electrical spark-timing gear, machinery necessary for suction and compression of explosive charges of gas, mechanical parts for control of valves, and the like.

Suction and compression may be conveniently obtained by a double-acting piston, M, (contained within a cylinder, N, connected by a piston-rod, pr, through a connecting-rod, cr, to a crank-shaft, Cs, which is mechanically connected to D1 (or D2) so as to produce one complete backward and forward stroke of the piston, M, for every half-revolution of the rotor, A, as shown in Figure 3. The piston, M, shall, at the same time as it is sucking a charge of explosive gas through the valve, O, (valve, P, being shut at this time), compress a previously-sucked charge of gas on the other side of M, and expel the compressed mixture through valve, Pp, to cylinder-head, Y. At the end of this stroke, M moves back, sucking a charge of gas through valve, Oo, (the valve, Pp, now being shut), and in the same operation the charge of gas previously sucked through valve, O, is now being compressed and expelled through valve, P, to cylinder-head, Y1.

In this manner, it is practicable to utilise one suction-compression chamber for each adjacent pair of cylinder-heads on the stator, G, and such suction-compression chambers may be arranged on either side of the stator, G, at any required distance from one another. (The said distance, as shown in Figure 2 of the accompanying drawings, is 180 degrees). The angle of drive of piston, M, may be, if found necessary to reduce the space occupied by the complete engine, altered so as to make an angle with the line, K, K, and not be parallel to K, K, as shown in Figure 4.

Lubrication of all moving parts is easily effected by normal methods.

The engine can be constructed to run in either direction. Fitting the cylinders, J, to rotors, A, A1 and the like, at an angle of 90 degrees to that shown in Figure 1 will result in the driving shaft, D, revolving in the reverse direction to that indicated in Figure 1.

An engine constructed on these lines may have one or more rotors, and one or more stators. Each stator may have one or more cylinder-heads affixed thereto. Each rotor may have one or more cylinders carried thereon or therein. Each stator may have one or more exhaust ports. Each complete engine may utilise the exhaust gases or steam to add to power generated, as previously stated, and illustrated in Figure 4. A pair or more engines, substantially as described, may be mounted in line with one another, and coupled to a common driving shaft, or mounted in the same plane, but parallel to one another and so coupled together by suitable gearing as to drive one common shaft. When mounted parallel to one another, the directions of rotation of individual engines may be opposite to one another so as to reduce vibration to a minimum.

In view of the fact that rotors, A, and the like, may be built up in the form of open wheels, this type of engine offers very excellent means of cooling all parts such as cylinders, J, pistons, R, and the like, by virtue of the fact that the said parts themselves are cutting the atmosphere, (when the engine is operating), at sufficient speed to induce an intense draught of air. This automatic cooling may be controlled or supplemented, as desired, by such means as fans, and the like.

A suggested method of utilising exhaust gases or steam in an engine employing the principles described in the aforegoing is shown in Figure 4 of the accompanying drawings. As previously made clear, when the engine is functioning, exhaust gas or steam is expelled through exhaust ports, K, and K, (as in Figure 1), at pre-arranged times. With an engine substantially as shown in Figure 1, however, the exhaust will be made through both ports simultaneously. If we have another pair of exhaust ports in line with the aforesaid ports, K, K, but affixed on the stator opposite the rotor, A1, (in Figure 2), then the exhaust from ports, K, and K, opposite rotor, A1, will take place when A, and A1, have moved through one quarter of a revolution from the point where the exhaust gases or steam were taken from cylinders in rotor, A.

If a rotor, AX, as shown in Figure 4, be made somewhat similar in construction to rotors, A, and A1, (as previously described), and mounted on the main driving shaft, D, and so caused to revolve inside a stator, Gx, (as in Figure 4 of the accompanying drawings), it is possible to affix four cylinders of somewhat similar construction to J, as aforegoing, to such rotor, AX. Stator, Gx, may be fitted with two cylinder-heads, or apertures, hX, each connected to a dual low-pressure feed pipe, Zp, XP, and ZP1, XP1, as shown in Figure 4. Stator, Gx, may have two exhaust ports, Kp, Kp.

If now we take the exhaust gases or steam from opposite cylinders, J, in rotor, A, via exhaust ports, K, and K, to cylinderheads, hX via pipes, Zp and Zp1, the forces applied to the faces of pistons, R, in cylinders, Jx1, and Jx3, will contribute to the movement of the main shaft, One quarter of a revolution later, the greatly expanded gas or steam in the two cylinders, Jx1 and Jx3 will be finally expelled, by normal action of the pistons, R, through exhaust ports, Kp, Kp, to the atmosphere or, via a form of silencer (if it is considered necessary), to the atmosphere. It is, however, provided, that, if development of this invention leads to even higher efficiency than is at present anticipated and it is found to be economical and practicable to further utilise low pressure gases or steam after expulsion from such cylinders, Jx1 and Jx3, such low pressure gases or steam may be again utilised in further low pressure cylinders prior to final expulsion from the engine.

At the same moment of expulsion of gases or steam from Jx1 and Jx3 in Fig. 4, exhaust gases or steam taken from opposite cylinders in the rotor, A1, in Figure 2, are led through their exhaust ports, K and K, to the low pressure feed pipes XP and XP1, (shown in Figure 4) to cylinder-heads or apertures, hX, and

so to cylinders, $Jx4$ and $Jx2$, which are nearly, or exactly, in line with hX and hX, where the pressure exerted on pistons, R, in these appropriate cylinders is again utilised to contribute to the energy developed by the engine as a whole. One quarter of a revolution later, $Jx4$ and $Jx2$ will exhaust their contents of gas or steam through ports, Kp and Kp, and simultaneously, $Jx1$ and $Jx3$ will receive another impulse of low pressure gas or steam, and so the cycle of operations is continued.

Such low pressure cylinders, $Jx1$ and the like, may be constructed similarly to high pressure or primary cylinders, J, and the like, as previously described, and the rotors, AX and the like may approximate in form and design, rotors, A, A1 and the like. The stators, Gx, and the like, may be affixed to a common bed, by brackets such as, H. Similar to the statement made in the fifth paragraph, aforegoing, the placement of cylinders, $Jx1$, $Jx2$, $Jx3$, $Jx4$, and the like, may be at any angle found most suitable or efficient, and the cylinder walls between stops, X, and the rotor-face, E, (in Figure 4) need not necessarily be straight, but may be shaped as found necessary. To ensure the full pressure of the low pressure gases or steam being directed to the appropriate cylinders via the apertures, hX, it may be arranged that valves shall prohibit the passage of gas from Zp to XP, or from Zp1 to XP1, and from XP to Zp, or from XP1 to Zp1; obviously such valves shall operate at the junctions of the pipes Zp, XP and Zp1, XP1.

Lubrication of all moving parts in such stators and rotors utilising low pressure gases or steam may be effectively obtained by normal methods.

Dated the 28th day of February, 1930.

WM. R. CROSS,

A. E. HAY.

COMPLETE SPECIFICATION.

Improvements relating to Rotary Engines.

We, William Robert Cross, a British Subject, of 10, Avenue House, Henry Street, St. John's Wood, London, N.W. 8, and Albert Edward Hay, a British Subject, of Oak Lodge, Nathan Road, North Wembley, in the County of Middlesex, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to improvements in rotary engines, and has for its chief object to provide an improved and comparatively simple engine of high efficiency. The main parts of the engine may conveniently be described as stators and rotors since one set of the parts (the rotors) revolve inside the other parts (the stators). Both bodies have smooth contiguous surfaces in close juxtaposition to one another, and they are prevented from binding or gripping one with the other by a film of lubricating medium, which film serves not only to allow free movement of the rotors within the stators, but also assists in preserving gas or steam-tight joints between such rotors and stators. Cylinders are carried on or within the rotors, and cylinder-heads are fixed on or may be cast in the stators, the arrangement being such that during certain intervals, during the rotation of the rotors, the cylinders therein register with the cylinder heads in the stators. It is at this time that the power impulse is obtained, as hereinafter described. The cylinders and cylinder-heads may be arranged in any desired manner in the rotors and stators respectively so as to obtain at least two power strokes from each cylinder in every revolution of the rotors, as hereinafter described.

In this invention, a successful endeavour has been made to reduce moving and reciprocating parts to a low number, and to obtain a high power-weight ratio by increasing the number of power strokes per revolution of the driving shaft. A four-cylinder internal combustion or like engine, of the nature described herein, will give eight or more power strokes per revolution. The principle of this engine may be applied to steam-driven and Diesel or Semi-Diesel motors. When the exhaust gases or steam are fed to low-pressure cylinders, as later described, then the number of power strokes per revolution will be further increased.

It has heretofore been proposed to provide a rotary engine comprising a rotor and stator, the rotor having cylinders within which are arranged cushioned pistons, and the stator having cylinder heads to which the explosive charge is fed under compression, and it has been proposed in this construction of rotary engine to arrange the exhaust ports close

to the cylinders heads so that there is interconnection between the cylinder heads and the exhaust ports at certain positions of the cylinders, the products of combustion thereby being free to pass through the exhaust ports to a bladed turbine.

According to the present invention, the rotary engine comprises one or more rotors within one or more stators, each of said rotors being provided with two or more cylinders, each having arranged therein a cushioned piston and each of the said stators having two or more cylinder heads to which the explosive mixture, steam or other driving medium is admitted under compression and also having a like number of exhaust ports alternating with the cylinder heads around the periphery of the stator in such a manner that intercommunication between the cylinder heads and the exhaust ports is impossible for any position of the cylinders, the arrangement being such that when the cylinders communicate with the cylinder heads, the power impulse is given.

In order that this invention may be the more clearly understood and readily carried into effect, we will proceed to describe the same with reference to the drawings accompanying our Provisional Specification which illustrate the application of the present invention to an internal combustion engine and in which

Figure 1 is a vertical section through the engine at right angles to the length of the main shaft,

Figure 2 is a horizontal section through the engine at right angles to Figure 1, and

Figure 3 is an end view of Figure 2 showing the arrangements for feeding the combustible mixture to the engine.

Figure 4 is a view similar to that shown in Figure 1 and illustrating a low pressure or secondary rotor or the rotor to which the exhaust gases from the high pressure or primary rotors are fed.

Referring now more particularly to Figures 1 to 3 of the drawings filed with the Provisional Specification, the engine comprises a rotor A, (which may be solid or built up of castings in wheel form) which is secured at its boss B by a key C to the main driving shaft D (see Figure 1). The rotor and shaft may, of course, be machined from one mass of metal. The rotor A is machined to a polished surface at its periphery E, so as to make, when suitably lubricated, (and, if necessary, fitted with gas-tight rings, such as those shown by way of example at *r*, in Figure 2) a gas-tight clearance from a polished and lubricated surface F on the inside of a stator G which surrounds the rotor. The stator G can be bolted to its bed by means of suitable brackets H (Figure 1) and cylinders J may be bored in, or secured to, the rotor A. Two or more cylinders may be provided in each rotor A, and they may be spaced at any required and suitable distance from one another around the periphery E. The cylinders J may be disposed at any angle which is found most suitable or efficient, and the cylinder walls between X and rotor-face E (Figure 1) need not necessarily be straight, as shown, but may be shaped as found necessary so as to reduce waste expansion space to a minimum and so as more efficiently to direct the driving pressure where it can do most work. Alternatively, the front faces of the pistons R may, if desired, be shaped in any suitable manner to reduce the waste expansion space. They may, for example, be so arranged as to be parallel to the line K—K when the pistons R are in the position shown in Figure 1. As shown in Figure 1, taking the base-line drawn through centres of exhaust ports K, K, the angle of the cylinders J, J, relative to the line K, K, is 45 degrees. The distance between cylinder-heads Y, Y, and exhaust ports K, K, may also be any one found most suitable but, as shown with lines drawn through centres of K, K, and *y*, *y*, the angle is 90 degrees, or in other words, the cylinders are placed diametrically opposite one another in the rotor A. Slidably arranged within the cylinders J are pistons R, the rods S of which pass through the bottom of the cylinders, as shown, and are surrounded by compression springs T which bear at one end on the bottom of the cylinder and at the other end on the underside of the piston so as normally to urge the pistons R away from the bottom of the cylinder. The outward movement of the pistons R is, however, limited, by a stop or abutment X provided in the cylinder. The stop or abutment X would, of course, be suitably disposed in accordance with the shape or form of the piston face to prevent the latter striking the stator.

Describing now the operation of the engine, according to the present invention, a charge of atomised gas is sucked through the induction pipe L (Figure 2) by a double-acting, or other suitable piston M working within a cylinder N affixed to the stator G (Figure 3). The cylinder N may be fixed centrally or otherwise between the rotors A and A1 on the stator G (Figure 2) so as to serve two cylinder-heads Y, Y1 through short induction pipes V and V1 (Figure 2).

The gas sucked into the cylinder N by

the piston M through the induction pipe L, via an automatically or mechanically operated inlet valve O (Figure 3), (the automatically or mechanically operated outlet valve P meantime being shut) is, after the rotor A or the rotor A1 has revolved through one quarter of a revolution, compressed by the return stroke of the piston M and forced through the valve P to cylinder-head Y1 (as shown in Figure 2). At the moment of end travel of M, the valve P shuts, and cylinder-head Y1 is then full of compressed and explosive mixture. The cylinder J then registers with the cylinder-head Y1, and at this moment a spark is caused at the sparking points of sparking-plug Q, the resultant explosion driving the piston R, in Figure 1, (which may be fitted with piston-rings *xV*) and piston guide rod S up against compression spring T which is anchored at its base to the bottom of the cylinder or to cylinder cover-plate U affixed to cylinder J, as shown in Figure 1. Means may be provided for advancing and retarding the spark so that the explosion may take place when the cylinder is out of register with the cylinder-head to a greater or less extent. The cylinder bottoms or cover-plates U have a hole W through which guide-rod S can travel. The direct push of piston R, caused by the explosion, is transmitted by the spring T to the rotor A which is caused to revolve in the direction of the line of drive of R.

Meanwhile, the other cylinder-heads, firing at the same time, are going through a similar cycle of operations, and the power derived is additive. A fraction of a revolution (which may conveniently be one quarter revolution when the cylinders are spaced, as above described) of the rotor A later, the expanded gas is expelled through an exhaust port K by the piston R which is forced back to its normal position of rest by the spring T. The piston R, on returning to its normal position of rest, comes against a suitable stop X which may be padded on the face nearest to R with shock absorbing material (see Figure 1). The gas expelled through port K is led either to the atmosphere or to low-pressure cylinders (as hereinafter described in connection with Figure 4), where its pressure may be further utilised to add to generated power.

A fraction of a revolution later (which may conveniently be one quarter of a revolution, as shown in Figure 1), the rotor A has reached such a position that the afore-mentioned cylinder J is in position to receive another exploded charge of gas, and so the cycle of operations is continued so that every rotor-cylinder can deliver at least two power strokes per revolution of A. The cylinders J may be constructed to have cooling fins such as Z to prevent undue heating.

The springs T may, if desired, be replaced by any practicable means, such as air-compression, whereby the sudden drive of the piston R may be partially relieved, although it is obvious that any substitute for the spring T must efficiently transmit the power generated by the moving piston R without loss.

All the cylinder-heads Y, Y1 and the like may, if desired, be in line with one another along the whole length of the engine, and the cylinders J, J1 and the like (in rotors A, A1 and the like) may be staggered at various angles relative to one another. With such an arrangement, and with explosions of gas timed to take place at desired moments, an even torque with very little vibration is obtained. For example, an engine having eight such rotors with two cylinders in each rotor (that is to say sixteen cylinders in all), will give thirty-two power strokes in each revolution of the main shaft D without taking into consideration the fact that additional power strokes can be obtained if the exhaust gases are utilised in low-pressure cylinders, as heretofore described and shown in Figure 4. In such a multi-cylinder engine, the rotor A may quite conveniently be constructed as one mass, if necessary, and not as several individual rotors, keyed to the main shaft D at each end. Such multi-cylinder rotors may, however, be machined, with the main shaft, out of one mass of metal.

The main shaft D drives the auxiliary shafts D1 and D2 through a two-to-one chain and/or gear and shaft drive, so that the shafts D1 and D2 shall revolve at twice the speed of the shaft D (see *dw*, *dw*1, and *dw*2 in Figure 2). The shafts D1 and D2, secured to the stator G by suitable brackets, such as *e*, drive all auxiliary parts of the engine, such as electrical generators, electrical spark-timing gear, apparatus necessary for suction and compression of explosive charges of gas, mechanical parts for control of valves and the like.

Suction and compression may be conveniently obtained by the double-acting piston M which is arranged within the cylinder N and is driven by a crank Cs, mechanically connected to the shaft D1 or D2 through a connecting rod *cr* and a piston rod *pr*. The piston M is arranged to complete one backward and forward stroke for every half-revolution of the rotor A, as shown in Figure 3.

The piston M will, at the same time as it is sucking in a charge of explosive gas through the valve O, (the valve P being shut at this time) compress a previously sucked charge of gas on its other side and expel the compressed mixture through the valve Pp to the cylinder-head Y. At the end of this stroke, the piston M moves back, sucking in a charge of gas through the valve Oo (the valve Pp now being shut), and in the same operation the charge of gas previously sucked in through the valve O is now being compressed and expelled through the valve P to the cylinder-head Y1.

In this manner it is practicable to utilise one suction-compression chamber for each adjacent pair of cylinder-heads on the stator G, and such suction-compression chambers may be arranged on either side of the stator G at any required distance from one another, the said distance, as shown in Figure 2, is 180 degrees. The angle of drive of piston M may be, if found necessary to reduce the space occupied by the complete engine, altered so as to make an angle with the line K, K and not to be parallel to K, K as shown in Figure 4.

Lubrication of all moving parts is easily effected by normal methods.

The engine can obviously be constructed to run in either direction since by fitting the cylinders J to rotors A, A1 and the like at an angle of 90 degrees to that shown in Figure 1 will result in the driving shaft D revolving in the reverse direction to that indicated in Figure 1.

An engine constructed on these lines may have one or more rotors, and one or more stators. Each stator may have two or more cylinder-heads in or affixed thereto and each rotor may have two or more cylinders carried thereon or therein. Each stator may have two or more exhaust ports. Each complete engine may utilise the exhaust gases or steam to add to power generated, as previously stated, and illustrated in Figure 4. A pair or more engines, substantially as described, may be mounted in line with one another and coupled to a common driving shaft, or mounted in the same plane, but parallel to one another and so coupled together by suitable gearing as to drive one common shaft. When mounted parallel to one another, the directions of rotation of individual engines may be opposite to one another so as to reduce vibration to a minimum.

In view of the fact that rotors A and the like may be built up in the form of open wheels, this type of engine offers very excellent means of cooling all parts such as cylinders J and the like by virtue of the fact that the said parts themselves are cutting the atmosphere (when the engine is operating), at sufficient speed to induce an intense draught of air. This automatic cooling may be controlled or supplemented as desired by such means as fans, and the like.

One suitable method of utilising the exhaust gases or steam in an engine employing the principles described in the aforegoing, is shown in Figure 4. As previously described, when the engine is functioning, exhaust gas or steam is expelled through the exhaust ports K and K (as in Figure 1) at pre-arranged times. With an engine substantially as shown in Figure 1, however, the exhaust will be made through both ports simultaneously. If now another pair of exhaust ports is provided in line with the aforesaid ports K, K, but affixed on the stator opposite the rotor A1 (in Figure 2), then the exhaust through ports K and K, opposite rotor A1, will take place when A and A1 have moved through one quarter of a revolution from the point where the exhaust gases or steam were taken from cylinders in rotor A, in other words, exhaust will take place at every quarter revolution.

If an additional rotor AX, as shown in Figure 4, be made somewhat similar in construction to rotors A and A1, as previously described, and mounted on the main driving shaft D and so caused to revolve inside a stator Gx (as in Figure 4), it is possible to affix four cylinders in the said rotor of somewhat similar construction to J, as aforegoing. The stator Gx may be fitted with two cylinder-heads or apertures *h*X, each connected to a dual low-pressure feed pipe *Zp*, XP and *Zp*1, XP1, respectively as shown in Figure 4. The stator Gx may also have two exhaust ports Kp, Kp which lead to the atmosphere, a silencer or a further rotor, as hereinafter described.

If now the exhaust gases or steam from opposite cylinders J in rotor A are led via the exhaust ports K and K to the cylinder-heads *h*X via the pipes *Zp* and *Zp*1, the forces applied to the faces of the pistons R in the cylinders Jx1 and Jx3 will contribute to the movement of the main shaft. One quarter of a revolution later, the greatly expanded gas or steam in the two cylinders Jx1 and Jx3 will be finally expelled by the action of the pistons R, as described above, through exhaust ports Kp, Kp, to the atmosphere or via a form of silencer (if it is considered necessary), to the atmosphere. The springs on the pistons in the low pressure cylinders need not be so strong as those in the primary or high pressure

cylinders. It is, however, provided that, if development of this invention leads to even higher efficiency than is at present anticipated and it is found to be economical and practicable further to utilise low pressure gases or steam after expulsion from such cylinders $Jx1$ and $Jx3$, such low pressure gases or steam may be again utilised in further low pressure cylinders in a further rotor prior to final expulsion from the engine.

At the same moment of expulsion of gases or steam from $Jx1$ and $Jx3$ in Figure 4, exhaust gases or steam taken from opposite cylinders in the rotor A1 in Figure 2 are led through their exhaust ports K and K to the low pressure feed pipes XP and $Xp1$ (Shown in Figure 4) and so to the cylinder-heads or aperture hX. The exhaust gases are thus conducted to the cylinders $Jx4$ and $Jx2$ which are nearly, or exactly, in line with hX and hX, where the pressure exerted on pistons R in these appropriate cylinders is again utilised to contribute to the energy developed by the engine as a whole. One quarter of a revolution later, $Jx4$ and $Jx2$ will exhaust their contents of gas or steam through ports Kp and Kp and simultaneously $Jx1$ and $Jx3$ will receive another impulse of low pressure gas or steam and so the cycle of operations is continued.

Such low pressure cylinders $Jx1$ and the like may be constructed similarly to high pressure or primary cylinders J and the like, as previously described, and the rotors AX may approximate in form and design to the rotors A, A1 and the like. The stators Gx and the like may be affixed to a common bed, by brackets such as H. The positioning of the cylinders $Jx1$, $Jx2$, $Jx3$, $Jx4$ and their angle of inclination may be arranged as is found most suitable or efficient, and the cylinder walls between stops X and the rotor-face E, (in Figure 4) need not necessarily be straight, but may be shaped as found necessary to minimise unnecessary expansion space since the pistons R do not travel along these parts of the cylinder walls. As an alternative, it is also provided that the faces of the pistons R within the low-pressure cylinders $Jx1$ and the like may be inclined at any suitable angle relative to the inside walls of such cylinders, or be shaped in any suitable manner, so as to reduce unwanted or unnecessary expansion space between such piston faces and the orifices of the cylinders at the periphery of the rotor AX at E. To ensure the full pressure of the low pressure gases or steam being directed to the appropriate cylinders via the apertures hX, it may be arranged that valves shall prohibit the passage of gas from Zp to XP, or from $Zp1$ to XP1, and from XP to Zp or from XP1 to $Zp1$; obviously such valves shall operate at the junction of the pipes Zp, XP and $Zp1$, XP1.

Lubrication of all moving parts in such stators and rotors utilising low pressure gases or steam may be effectively obtained by normal methods.

Although this invention has been more particularly described as applied to an internal combustion engine employing explosive mixture which is ignited by an electric spark, it will be obvious that the engine with but slight modification may be arranged to operate on any other known principle, such as on the Diesel or semi-Diesel principle or it may be arranged to work as a steam engine. When using steam as the source of power, obviously the suction-compression arrangements such as shown in Figure 3 are unnecessary and under efficient conditions it may even be possible to dispense with valve gear such as P in Figure 1.

The engine, according to the present invention, has only a minimum number of moving parts which thus enables the efficiency to be increased and furthermore will be found to have a high power-weight ratio.

An engine of this type intended for automobile, motor launch or aeronautical service need, of course, only be capable of revolving in one direction. For the first two-named purposes, reversal of driving wheels, screws or propellers would be obtained by the use of normal reversing gears. An engine, according to the present invention, may also be fitted with other cylinders affixed to work at an angle of 90° to the normal cylinders together with suitable change-over valve-gear of normal type, thereby making the engine reversible without the use of gears for reverse driving, such as required in ships.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A rotary engine comprising one or more rotors within one or more stators, each of said rotors being provided with two or more cylinders, each having arranged therein a cushioned piston and each of the said stators having two or more cylinder heads to which the explosive mixture, steam or other driving medium is admitted under compression and also having a like number of exhaust ports alternating with the cylinder heads

around the periphery of the stator in such a manner that intercommunication between the cylinder heads and exhaust ports is impossible for any position of the cylinders, the arrangement being such that when the cylinders communicate with the cylinder heads, the power impulse is given.

2. A rotary engine, according to Claim 1, in which the pistons are provided with piston rods which extend through bearings in the bottom of the cylinders, compression springs being provided between the bearings and the underside of the pistons, substantially as described.

3. A rotary engine according to either of the preceding Claims 1 and 2, in which the cylinders are provided with cooling fins, substantially as described.

4. A rotary engine according to any of the preceding Claims in which compressed combustible mixture is supplied to the cylinder heads by means of a pump driven from the engine shaft.

5. A rotary engine according to any of the preceding Claims 1 to 3, in which steam or like working medium is fed directly or through suitable valves to the cylinder heads.

6. A rotary engine according to any of the preceding Claims 1 to 3, adapted to work on the Diesel or semi-Diesel principle.

7. A rotary engine according to Claim 4, in which the pump is double acting and is arranged to supply a pair of cylinder heads, one cylinder-head being disposed to feed the cylinder (or cylinders) in one rotor, and the other cylinder-head being arranged to feed the cylinder (or cylinders) in an adjacent rotor.

8. A rotary engine according to Claim 7 in which double-acting pumps, substantially as described, may be disposed in various positions around the engine so as to feed any equivalent number of pairs of cylinder heads.

9. A rotary engine according to Claims 1 to 8, in which the exhaust gases or steam from the cylinders are fed to a low pressure rotor secured to the main shaft, in order to assist the rotation of the same.

10. A rotary engine according to Claim 9, in which the low-pressure rotor is provided with cylinders in which are arranged cushioned pistons, substantially as described.

11. The improved rotary engines having their parts constructed, arranged and adapted to operate, substantially as described with reference to the drawings lodged with the Provisional Specification.

Dated the 9th day of October, 1930.

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Agents for the Applicants.

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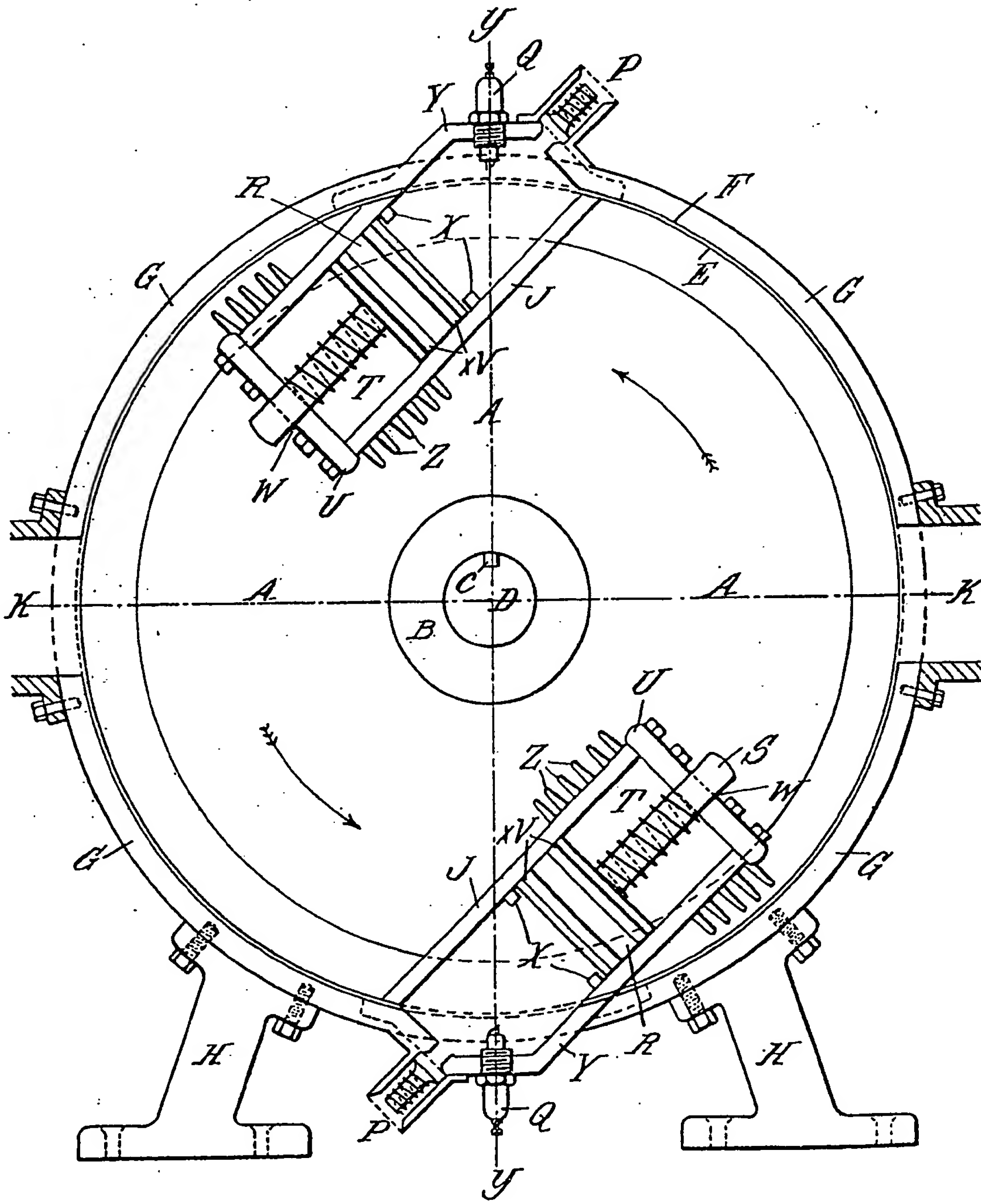
Fig. 1.



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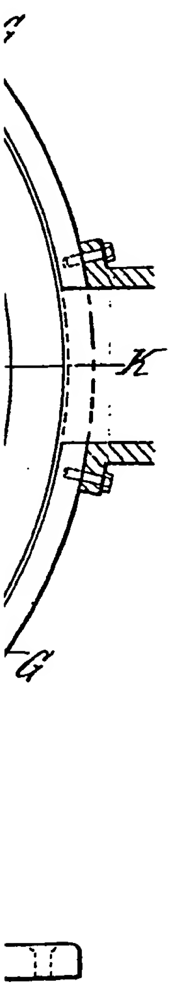
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Fig. 2.

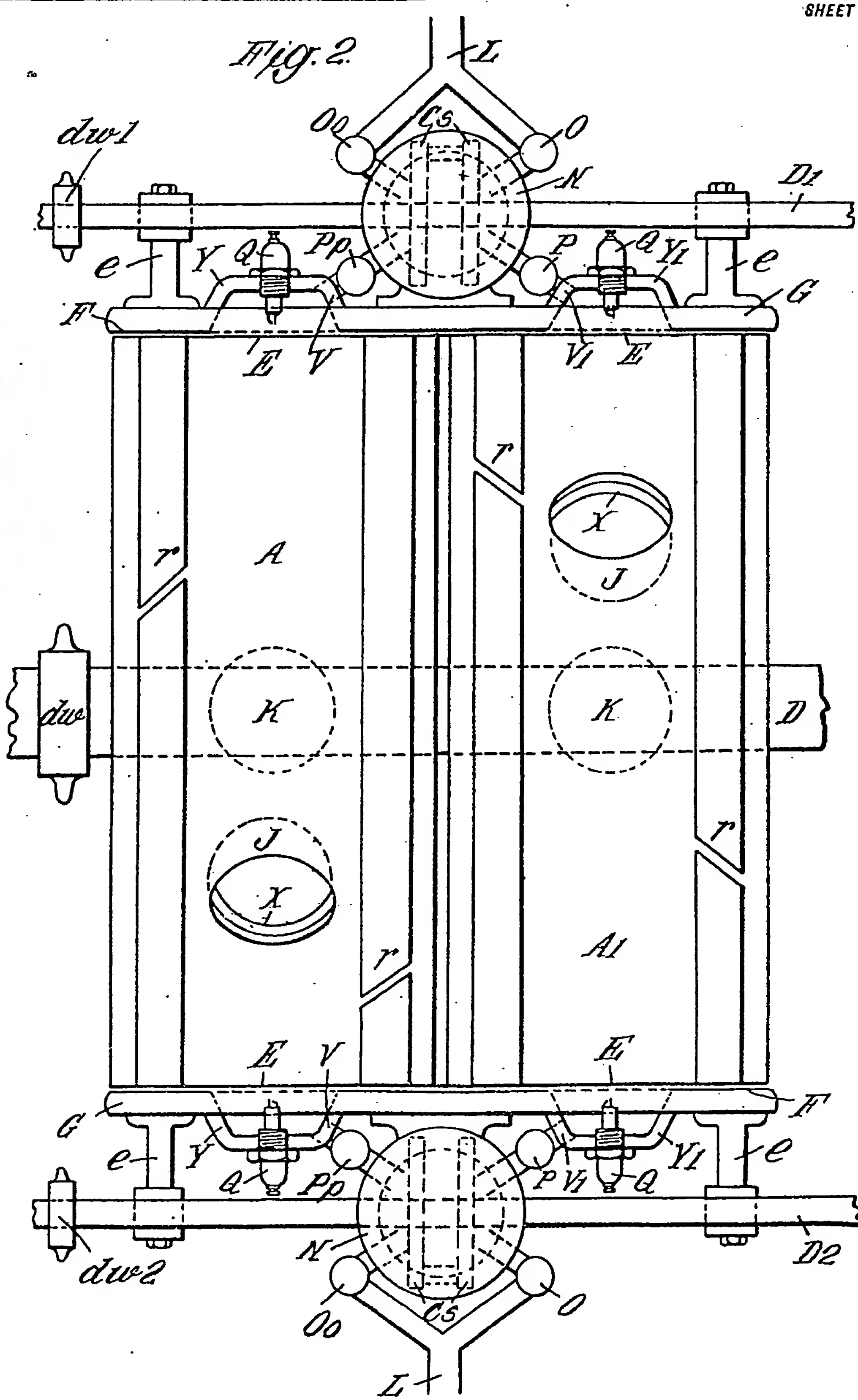
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Fig. 1.

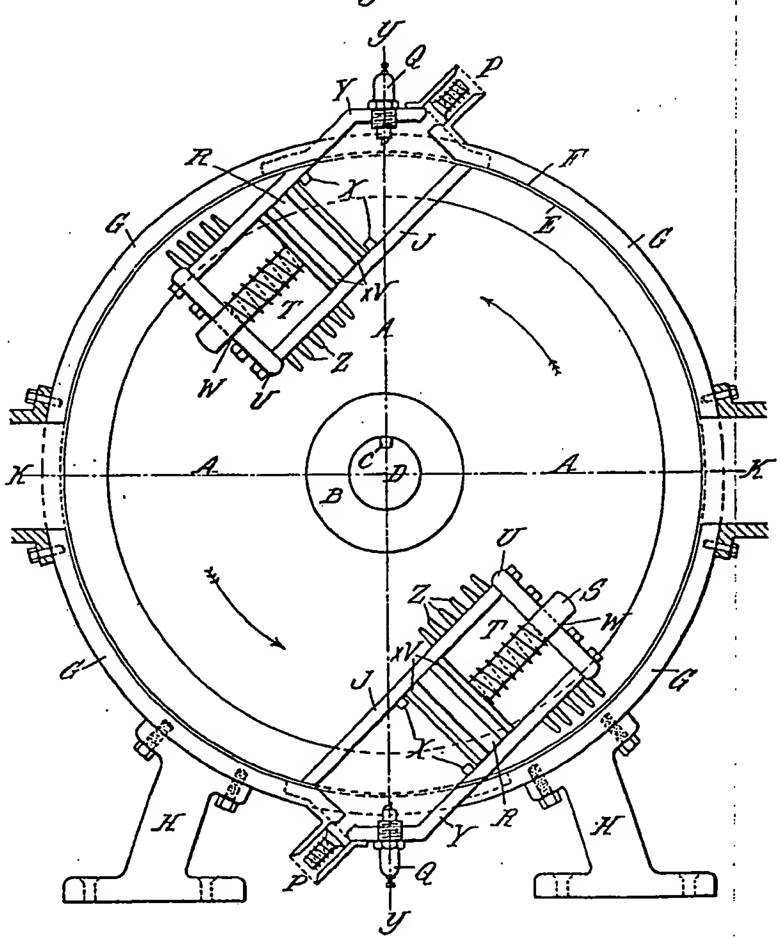
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Fig. 2.

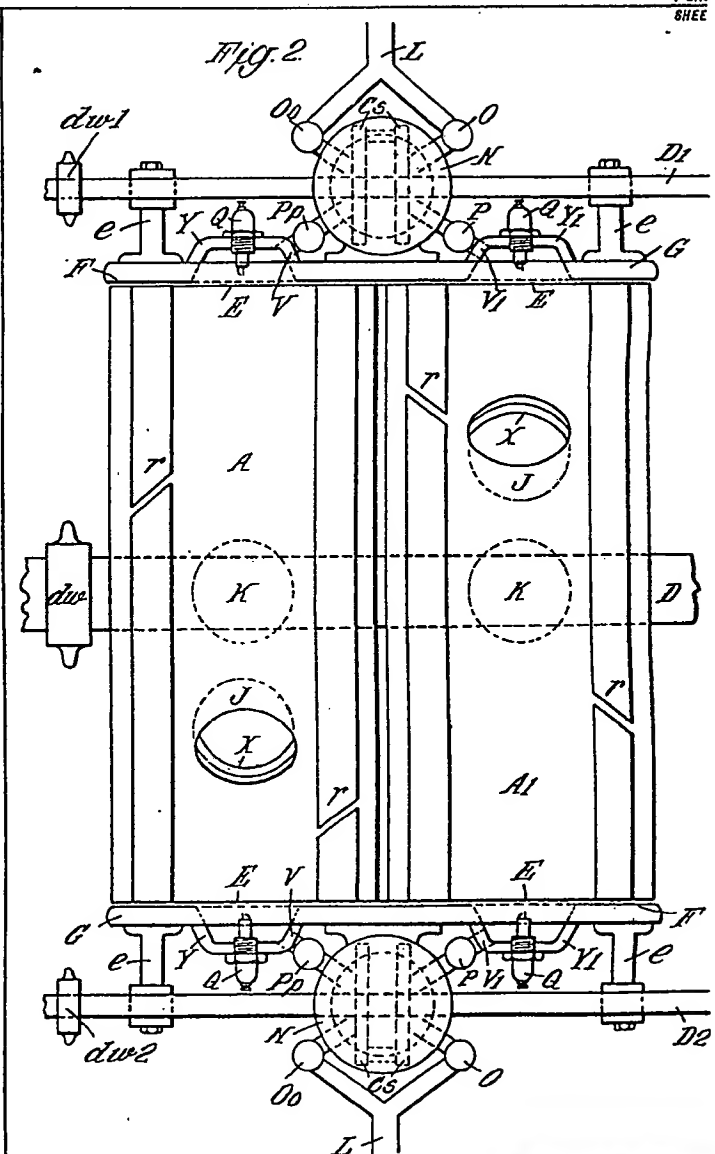
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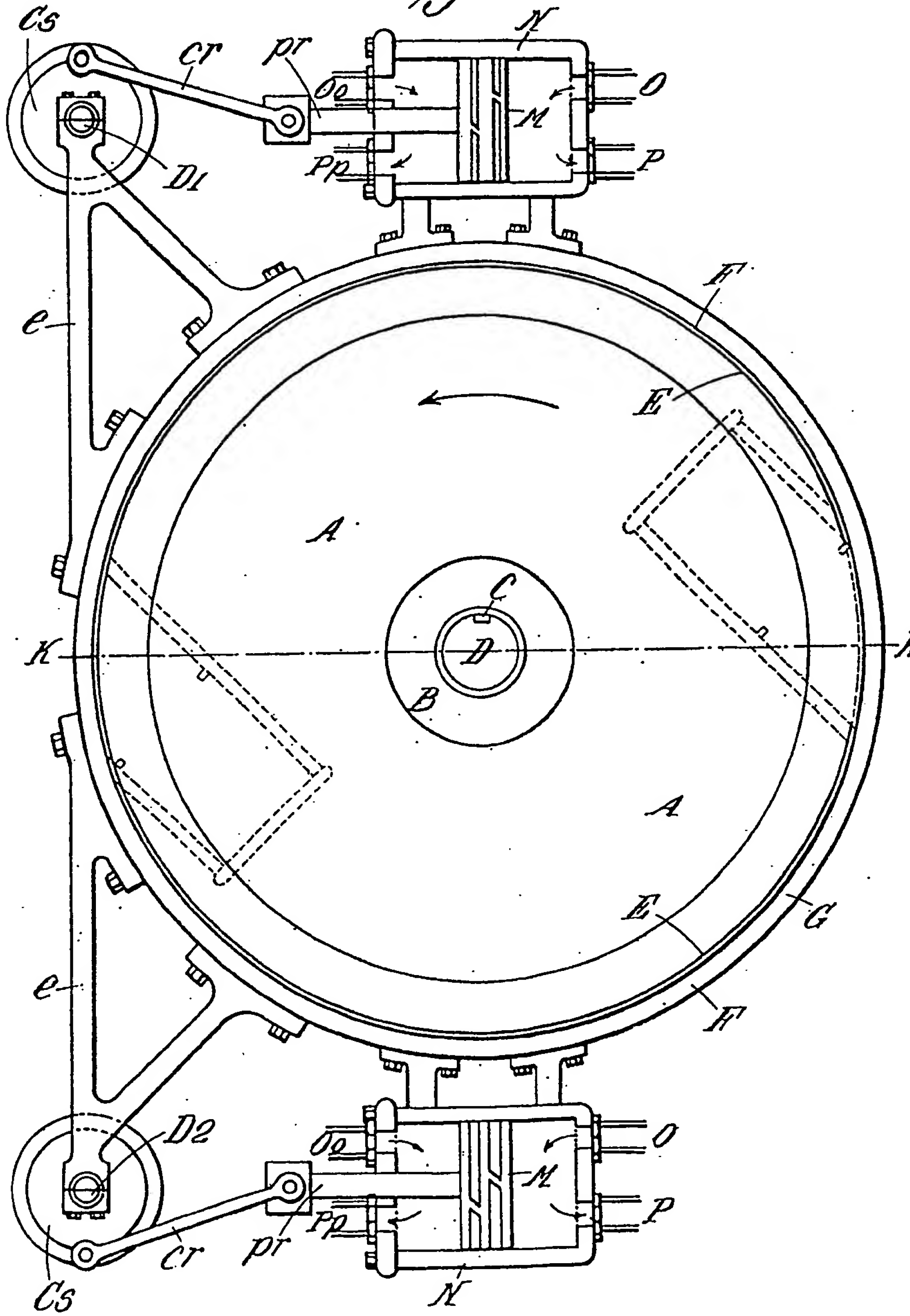
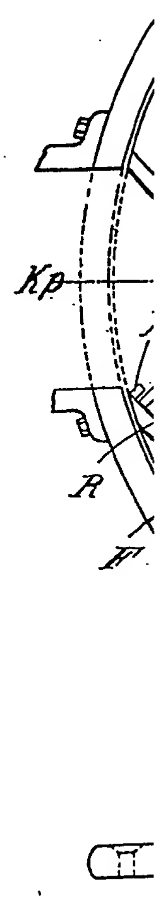
Fig. 3.





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SHEET 3

4 SHEETS
SHEET 4

Fig 4.

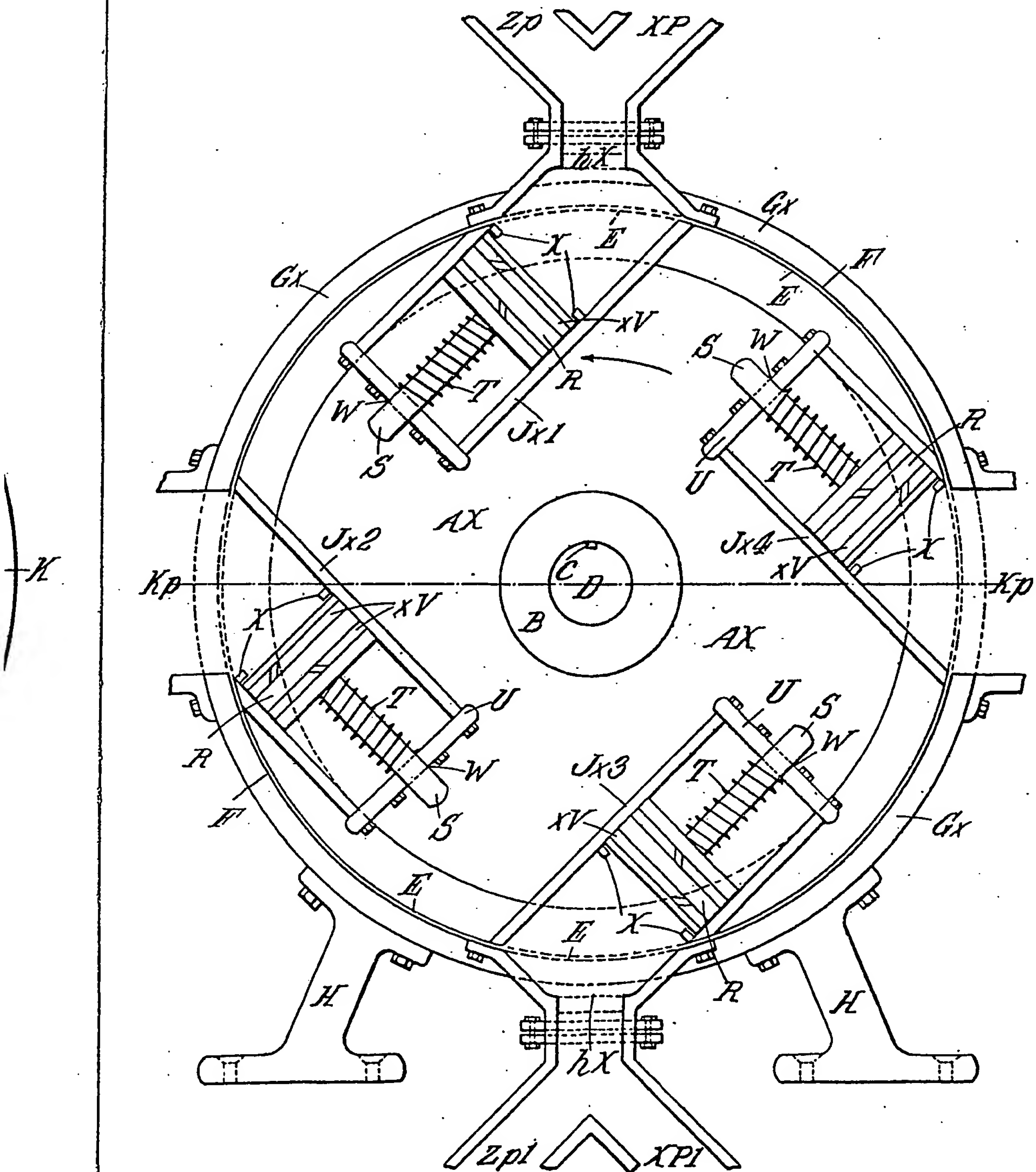

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Fig. 3.

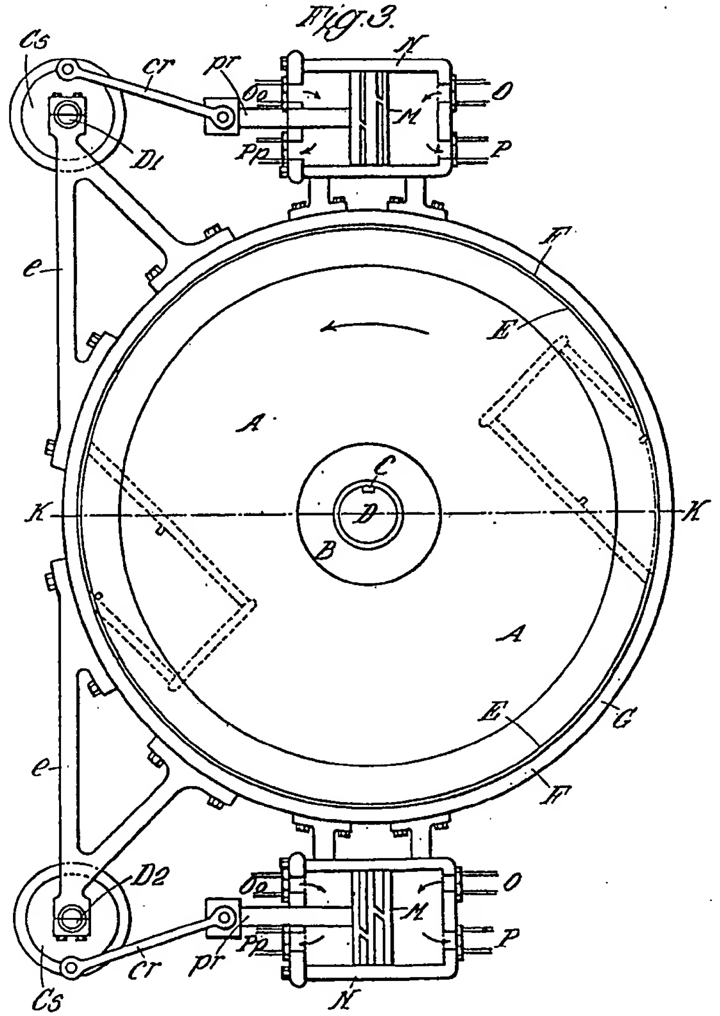
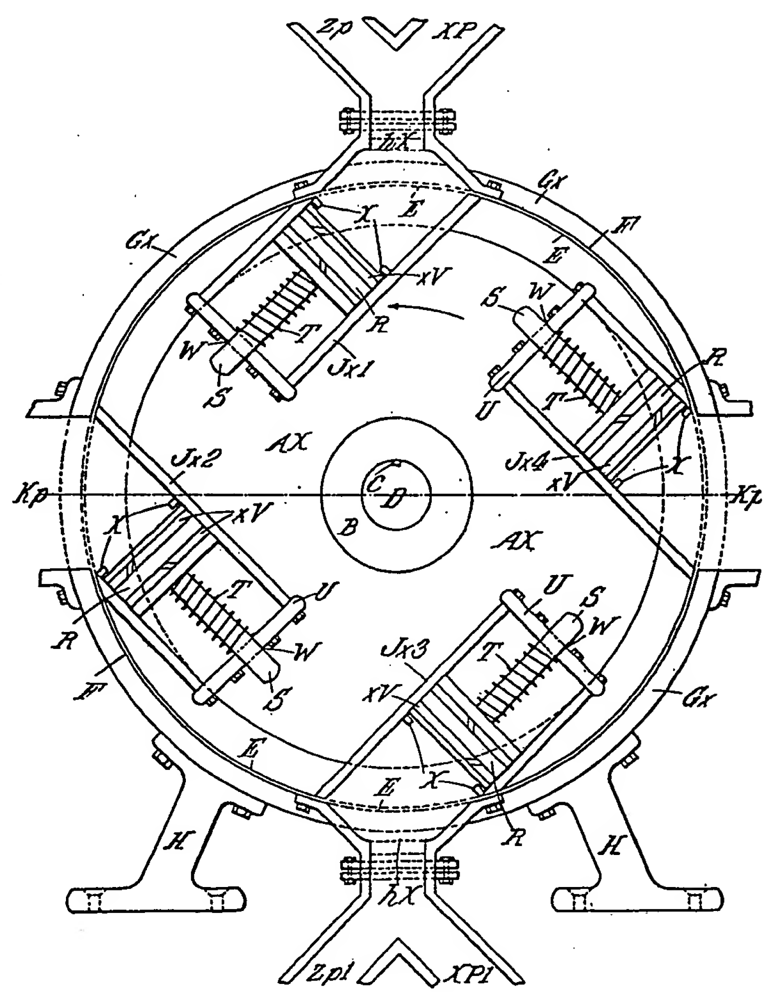


Fig. 4.



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